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DEVELOPMENT OF A VIRTUAL ITINERARY WITH HBIM AND GIS

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ABSTRACT:
This study explores the potential of Heritage Building Information Modeling (HBIM) and Geographic Information Systems (GIS) for assessing tourist visitation and managing public use of heritage buildings. By integrating these tools, the research aims to improve preventive maintenance and conservation management in culturally significant buildings and urban outdoor spaces. The findings demonstrate the value of HBIM and GIS in handling spatial information and facilitating reliable decision-making for tourist itinerary design and visitor flow management. By examining three buildings of the highest degree of protection as assets of cultural interest, the information obtained can be extrapolated to a municipal management network that encompasses numerous urban models. The integration of databases enables the combination of data at different scales, from the building level to the territorial level, involving all relevant stakeholders from various disciplines. The results highlight the importance of using digital tools in the context of heritage architecture and public use management, promoting more sustainable practices in the preservation and conservation of our cultural heritage.

1. INTRODUCTION

1.1 Background

This paper aims to present the initial outcomes of a research project focused on developing a prototype database using 3D models generated through GIS and HBIM methodologies. This research is motivated by the growing importance of cultural heritage conservation and the need for innovative, technology-driven solutions to address challenges in the cultural tourism sector. As a case study, the city of Valencia, Spain, with one of the largest historic centres in Europe, is examined in detail. (Figure 1)

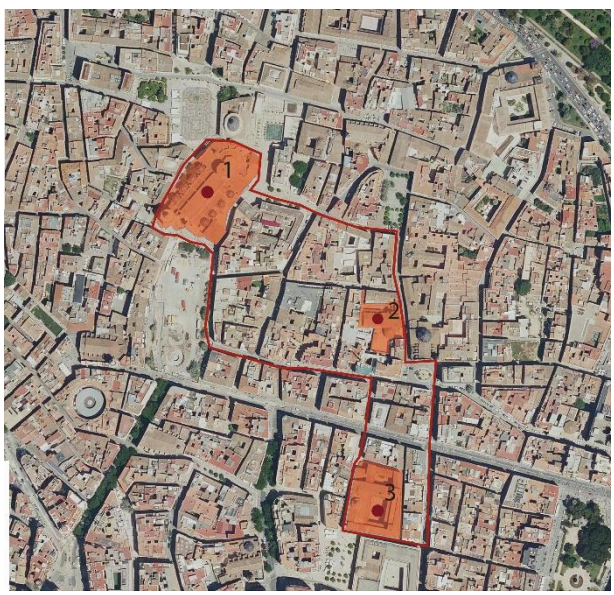


Figure 1. Orthophotos with the delimitation of the area of the historic Centre of the Metropolitan: (1) the Cathedral; (2) the medieval complex of San Juan of the hospital; (3) the Royal College Seminary of Corpus Christi.

Cultural heritage conservation is a vital aspect of sustainable development within the cultural tourism sector, encompassing public administrations, the scientific community, and society at large. With increasing public interest in cultural heritage and uncoordinated planning of heritage assets, there is a risk of degrading these valuable resources (Garcia-Hernandez, 2003). Furthermore, the recent pandemic has underscored existing deficiencies in the sector, particularly the lack of adequate planning and coordination among different actors, such as heritage, urban, and tourism, as well as the absence of technological means in public use management.

To address these challenges, digital twins, particularly 3D models with semantic information of cities and historic centres, have emerged as essential tools for risk control, planning, analysis, and visualization. However, the rapid accumulation of data creates challenges in handling different temporal versions of virtual 3D models, especially for cities and historic centres. Many existing city modeling implementations lack the ability to process changes automatically and efficiently, including visualization, semantics, geometry, topology, structure, level of detail (LoD), auxiliary means, and scope.

To overcome these limitations, this study proposes a specific conceptual approach for introducing necessary information for stakeholders in an interoperable manner. It incorporates two mathematical methods from Nguyen and Kolbe1 (2022) for counting people and monitoring sensor-derived environmental data. Salvador-García's (2020) research demonstrates the feasibility of managing public use of a monument through HBIM and GIS.

The prototype database incorporates various HBIM models for buildings, urban spaces, streets, and squares. Additionally, documentary information for different virtual alternative itineraries in the urban environment will be linked to a GIS model of the Historic Center. By integrating GIS and HBIM methodologies, the project aims to develop a comprehensive, technology-driven solution that addresses the challenges faced by

the cultural tourism sector, ensuring the sustainable conservation and effective management of heritage assets.

1. 2 Literature Review

The literature review examines the development and application of HBIM and GIS systems in managing public use of heritage assets, following the framework proposed by Zupic and Čater (2015). This approach allows researchers to understand the current state of the art, relevant previous studies, and to focus on specific aspects to maintain both qualitative and quantitative attention.

GIS has become a powerful tool in urban planning and resource management, leading to interoperability tests with BIM in various cultural heritage contexts. Key studies on HBIM and GIS capabilities, such as those by Pavel (2016) and Yang et al. (2020), provide valuable insights into the subject. The integration of HBIM in GIS has also been used in geographic contexts, with Martín and Murrillo (2020) evaluating potential risks to heritage assets in archaeological areas. Albea et al. (2016) have advanced in creating interactive maps of heritage complexes for public consultation through the Spatial Data Infrastructure Geoportal. Bruno et al. (2020) developed a web information system integrating BIM and GIS data to analyse the historic city and its main buildings over time.

BIM models are known for detailed building information specific to a site or location, while GIS provides information about the territory and infrastructure surrounding the building or site. Chenaux et al. (2019) discussed the integration of BIM with GIS as part of the workflow in creating Virtual Historic Dublin, designing an interactive 3D model of Dublin's historic centre. Studies incorporating diverse information about heritage asset management, such as Fassi et al. (2016), confirm HBIM's potential in managing building maintenance throughout its lifecycle. In the same vein, Bruno et al. (2018) made progress in documenting injuries through monitoring and sensor placement, significantly advancing preventive conservation and action planning. Martín and Murillo (2020) extended the application of HBIM to the field of archaeology.

The British Guide Historic Building Information Modeling (HBIM) (2017) suggests that HBIM is an innovative system that enhances cultural heritage information management (Arayaci et al., 2017, Puerto, 2021). By facilitating collaborative work, geometric, semantic, and documentary information of heritage assets from various disciplines is gathered in a common repository for conservation and management. HBIM can also contribute to maintenance tasks and cultural dissemination (Lo Turco et al., 2016). However, few studies have focused on these applications (Salvador-García, 2020), who examines recreational carrying capacity (RCC) as defined by Manning and Lawson (2002) - the maximum acceptable visitor impact level in a heritage space before resource conservation and visitor experience quality are compromised.

Currently, limited research exists on the use of HBIM and GIS methodologies for managing tourist visits, with the exception of Salvador's team's work (Salvador-García et al., 2020).

1.3 Research Objectives

This research aims to present partial results of the efforts to develop a prototype information repository using the ArcGIS Pro platform. This involves the application of GIS and HBIM methodologies and associated technologies, including reality capture (RC), data processing, scanning registration, 3D modeling, and information for preventive maintenance. The study is conducted within the context of one of the strategic actions of the Special Protection Plan of Ciutat Vella for managing the Historic Center of the Municipality of Valencia (Spain), approved on February 13, 2020, PEP Ciutat Vella, 2022. The objective is to create a 3D-GIS model of a portion of Valencia's Historic Center, encompassing complex structures such as the Metropolitan Cathedral, the Royal College Seminary of Corpus Christi, the medieval complex of Sant Juan del Hospital, and the surrounding urban environment. This model will be used to estimate visitor volume accessing not only specific cultural heritage site but also to analyse their mobility patterns through direct counting methods based on audio-visual images recorded by fully anonymized mobile phones. The study builds upon the innovative use of HBIM applied to the church of Sant Juan de Hospital de Valencia, with the results extrapolated to the other two buildings and unique outdoor spaces within the urban environment.

Additionally, this study emphasizes the delineation of the protection environments for the three monuments situated within the urban morphological structure. This delineation allows for the identification and distinction of various peculiarities that define the urban fabric while recognizing the developmental evolution and motivating elements. The selected areas for study correspond to the central area of La Seu-Xera, Calle la Paz's location, and the former University area ((López González et al., 2020)

2. METHODOLOGY

To accomplish these objectives, a methodology was designed alongside the accompanying work technology to address a problem related to heritage architecture and its public use. The Design Science Research (DSR) method was chosen as it follows the five stages suggested by Vaishnavi et al. (2004) and Chaves et al. (2016) for Design Sciences:

1. Identify the problem: through the analysis of the scientific literature.
2. Understand the problem: through the analysis of cultural tourism planning in the proposed case studies, with all three cases under the same management body.
3. Develop a solution: by creating a Protocol that integrates HBIM-GIS functions related to cultural tourism planning and property conservation.
4. Implement the solution: by applying the protocol to case studies.
5. Evaluate the solution: by assessing the Protocol's effectiveness, identifying potential changes and improvements, and analysing the exportability and transferability of results to other situations.

Figure 2. illustrates the process of the methodology adopted by this research.

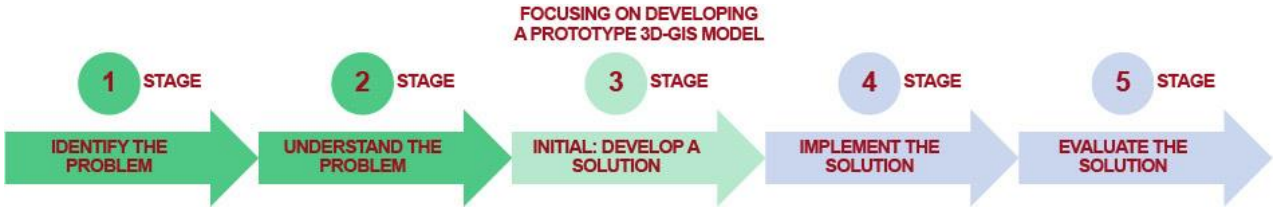


Figure 2. The results presented in this contribution correspond to stages

Effective conservation of heritage tourist attractions and quality recreational experiences rely on proper management of spaces (e.g., zoning, compatibility of uses, preventive maintenance, etc.) and visitor flows. To achieve this, it is crucial to understand the volume, distribution, and mobility of visitor flows within heritage spaces. Tools such as recreational carrying capacity, visit pattern design, and visitor frequency studies are essential for managing various attractions and improving the governance of Destination Management Organizations (DMOs), as noted by Baggio and Scaglione (2017). Salvador García's work (2020) was the first to implement a tourist visit tour within an HBIM model, identifying the involved agents, needs, traditional work processes, and HBIM's potential in public use management (Salvador-García, et al., 2022).

Regarding BIM and GIS integration, Castán (2022) successfully developed a digital graphic itinerary model of architectural heritage within a geographical area. This tool facilitated dissemination and utilization among various users through a Web Portal integrating a cartographic viewer with access to a WebGL-based point cloud manager and the HBIM-GIS information repository. These investigations provided guidance on creating GIS models.

Le Corre et al. (2012) and subsequent authors (Spenceley et al., 2021) analysed direct and indirect visitor counting methods. Direct methods include in situ counts, counts from photographs and still satellite images, automated counts using mechanisms (turnstiles, infrared, etc.), and counts from automated photographs or video cameras located in strategic places. The emergence of new image-based artificial intelligence technologies has enabled the automation and optimization of people quantification (Wang et al., 2020).

With these studies as precedents, the implementation of information using the referred tools became more accessible, facilitating the creation of the first 3D-GIS model prototype for a Historic Center.

3. RESULTS

The results obtained in this first stage of development are the following:

3.1 Reality Data Capture

The process of capturing geometric spatial reality and gathering pertinent information for cultural management and maintenance was conducted in the area encompassing the Seu-Xerea and Universitat neighbourhoods, where the three buildings are situated. A Leica RTC360 laser scanner and its accompanying Cyclone software were utilized for this purpose. It is important to note that documenting heritage buildings necessitates specific Levels of Detail (LoDs) or Levels of Development. The outcome of the laser scanning process was the creation of a 3D point cloud-based virtual itinerary (Figure 3), which was georeferenced using predefined survey benchmarks obtained with a total station. Point clouds were subsequently exported, connected, and interrelated through a merged BIM model. Additionally, point clouds were implemented in Revit for digital modelling (Figure 4).

Data acquisition for the Real Colegio Seminario de Corpus Christi, Metropolitan Cathedral, and the Church of Sant Juan of the Hospital performed using FARO Focus Premium, focus 360, Focus 3D, and FARO Freestyle handheld scanner. The collected data was subsequently processed using the FARO SCENE software.

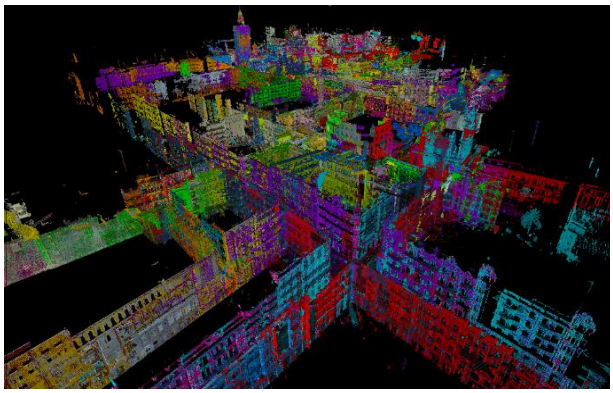


Figure 3. Registration of clusters of laser scans of cultural routes to create a point cloud in the Leica® Cyclone Register 360 software.

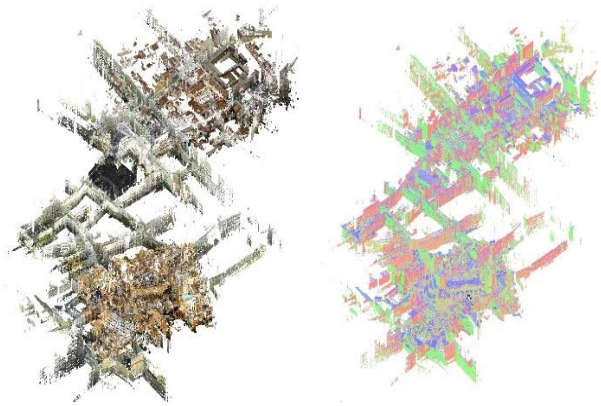


Figure 4. Integration of point clouds of the Metropolitan Cathedral of Valencia the Royal College Seminary of Corpus Christi and the medieval complex of San Juan of Hospital made in Autodesk® Revit software.

3.2 Collection of Tourist Information

The process of collecting tourist information involves automatically counting people using video images captured by two mobile phones, followed by image processing and the application of artificial intelligence for automatic people detection. The data gathered so far are from the Sant Juan del Hospital complex and the Metropolitan Cathedral. The mobile

phones utilized were basic Samsung devices (Galaxy A20e) with 32 GB of internal storage and a 5,000 mAh fast-charging battery. The captured images were processed using a Python script that enabled automatic people detection through artificial intelligence. This was made possible by the open-source CVLIB library (Ponnusamy, n.d.), which detects people and other objects in photographs using artificial intelligence algorithms. In this instance, the YOLOv3 model trained on the COCO dataset was employed (Collado et al., 2022) (Figures 5 and 6).

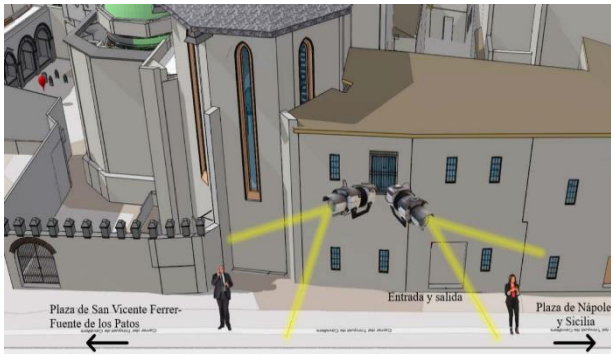


Figure 5. Distribution of the visual recording devices in the 3D model located on the balcony of Sant Juan Hospital, Valencia, relapse to the street Trinquete de Caballeros.

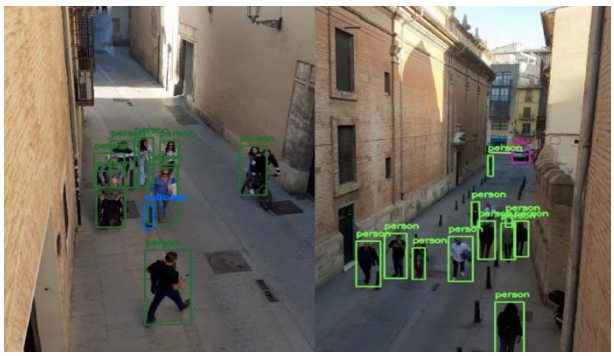


Figure 6. Automatic detection of passers-by from Piazza di Naples and Sicily (left) and from Piazza San Vicente Ferrer (right) towards of Sant Juan Hospital, Valencia.

3.3 Incorporating Models into GIS

The BIM models have been integrated into GIS through the ArcGIS online platform, which facilitates the combination of 2D and 3D map models from various sources within an intuitive interface. Simultaneously, it enables visualization, analysis, image processing, data management, and integration of information generated by the involved parties. A preliminary 3D-GIS model prototype has been developed, which incorporates the first LoD-200 HBIM models of the three buildings, along with information on the itineraries of the surrounding urban environments (Figure 7).

The three HBIM models of interest are at different Levels of Detail (LoD). The cathedral is at a basic geometric level (Figure 8), while the Seminary College of Corpus Christi is at the geometric level with textures obtained from the point cloud, both in the process of being implemented in Revit (Figure 9). A complete model of the Church of Sant Juan of Hospital is available in Revit (Figures 10 and 11).

Figure 7. ArcGIS environment and delimited with colours. The protected environments of each building superimposed on a layer of volumes of all the buildings of the city obtained from the cadastre.

Figure 8. The Cathedral geometric model in the GIS Platform.

Figure 9. Seminary College of Corpus Christi geometric model with textures obtained from the point cloud.

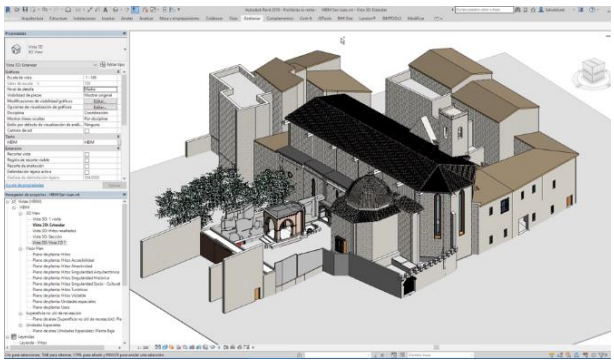


Figure 10. Model of the Church of San Juan del Hospital is available in Revit.

Figure 11. Complete model of the Church of San Juan del Hospital inserted in the GIS Platform

4. DISCUSSION

The results pertaining to the calculation of recreational carry capacity (RCC) demonstrate that the combination of HBIM GIS serves as a highly efficient digital tool. This is because system enables improved handling of spatial information linking semantic data, which in turn facilitates a comprehen understanding of the subject. (Figure 14 and 15.)

Moreover, it is evident that the Autodesk Revit software all for the integration of geometric and semantic informa generated by the stakeholders involved in public use planning management into the HBIM model. Concurrently, it offers reli support for decision-making in designing tourist itineraries managing visitor flow. Additionally, associated with impr visit management before they materialize, thus reducing the t and cost invested for achieving more sustainable management

5. CONCLUSIONS

This study demonstrates the potential of HBIM and GIS tools in assessing tourist visitation within building interiors and urban outdoor spaces. By integrating these tools and fostering their interoperability, we can effectively manage public use of heritage buildings and contribute to preventive maintenance and conservation management.

The research has shown that combining HBIM and GIS models offers a comprehensive approach to handling spatial information and facilitates reliable decision-making for tourist itinerary design and visitor flow management. The ability of HBIM to virtually analyse different alternatives can help anticipate and resolve risks associated with improper visit management, ultimately reducing time and costs for more sustainable management.

By examining three culturally significant buildings, the information obtained can be extrapolated to a municipal management network that encompasses numerous urban models, both buildings and urban spaces of historical heritage interest. The integration of databases enables the combination of data at different scales, from the building level to the territorial level, involving all relevant stakeholders from various disciplines. (Figure 12.)

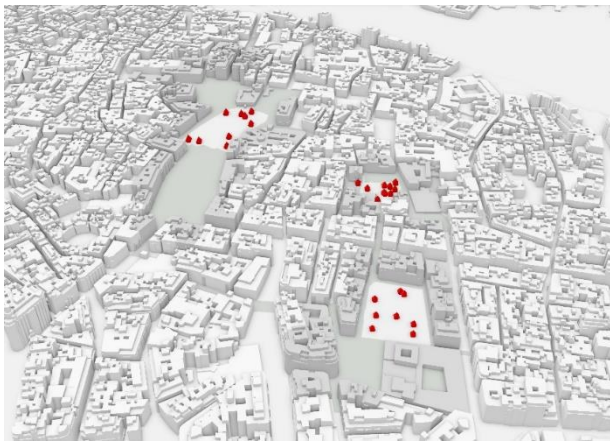


Figure 12. Various ArcGIS milestones. The most significant aspect is the footprint of the three buildings of the three models imported from Revit, which can be compared or used to generate statistics or shared tours.

In conclusion, this research highlights the value of using HBIM and GIS tools in studies of tourist frequentation, not only for building interiors but also for urban outdoor spaces. The integration of these databases allows for data combination at different scales, contributing to a more comprehensive understanding and management of heritage sites. This work paves the way for further exploration of these digital tools in the context of heritage architecture and public use management, promoting more sustainable practices in the preservation and conservation of our cultural heritage. (Figure 13.)

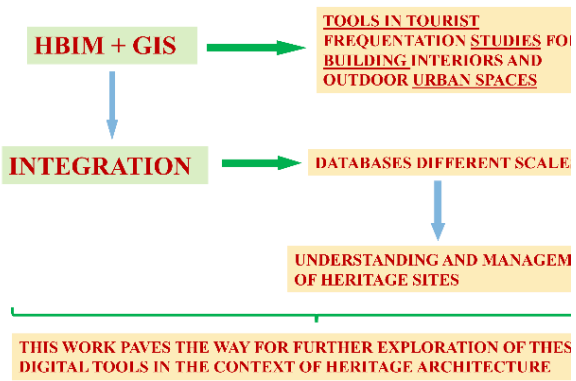
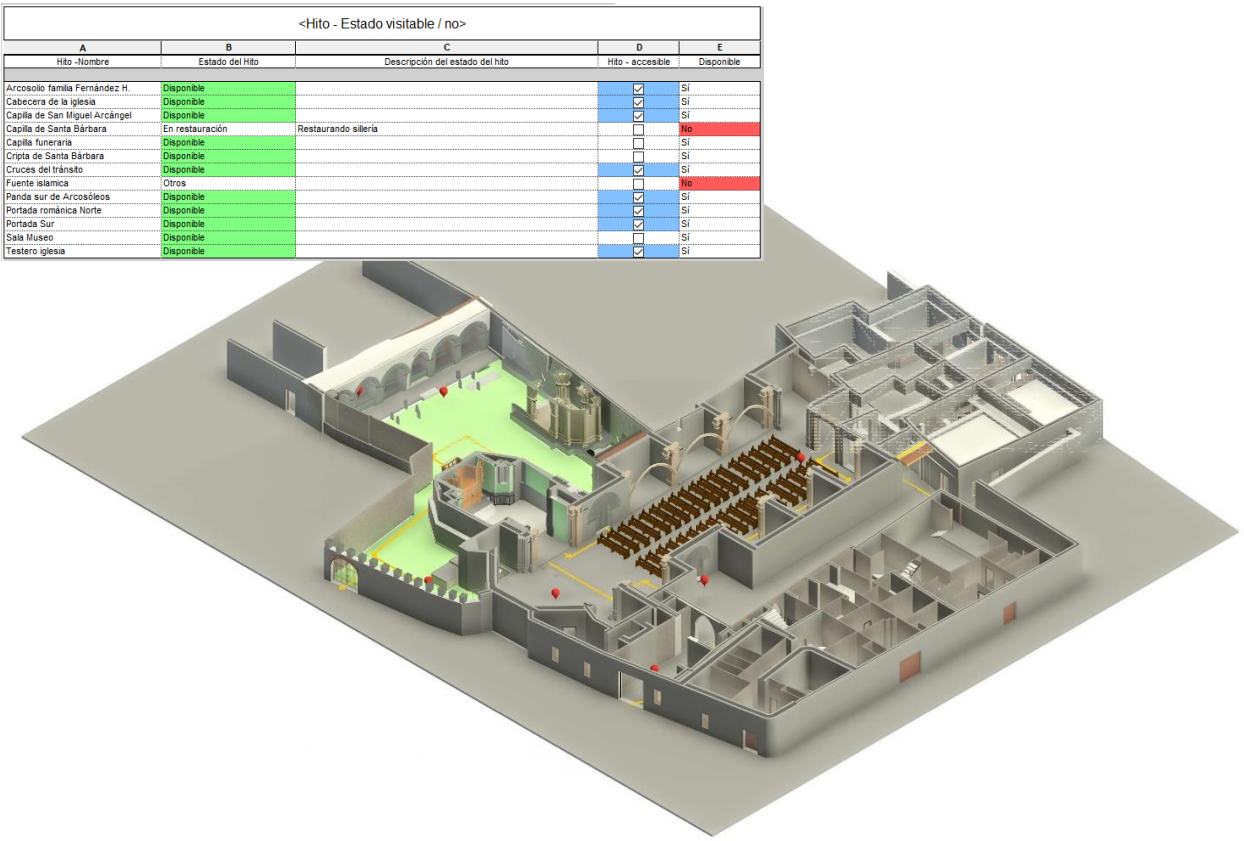


Figure 13. Diagram of the conclusion the potential of HBIM and GIS tools in assessing tourist visitation.



<Hito - Estado visitable / no>

A	B	C	D	E
Hito -Nombre	Estado del Hito	Descripción del estado del hito	Hito - accesible	Disponible
Arcosolio familia Fernández H.	Disponible		☑	Sí
Cabecera de la iglesia	Disponible		☑	Sí
Capilla de San Miguel Arcángel	Disponible		☑	Sí
Capilla de Santa Bárbara	En restauración	Restaurando sillería	☐	No
Capilla funeraria	Disponible		☐	Sí
Cripta de Santa Bárbara	Disponible		☐	Sí
Cruces del tránsito	Disponible		☑	Sí
Fuente islamica	Otros		☐	No
Panda sur de Arcosóleos	Disponible		☑	Sí
Portada románica Norte	Disponible		☑	Sí
Portada Sur	Disponible		☑	Sí
Sala Museo	Disponible		☐	Sí
Testero iglesia	Disponible		☑	Sí

Figure 14. A rendering obtained from the Revit model, where the milestones that are selected and the Table of Parameters for each element in the Revit model are observed the Church of Sant Juan del Hospital.

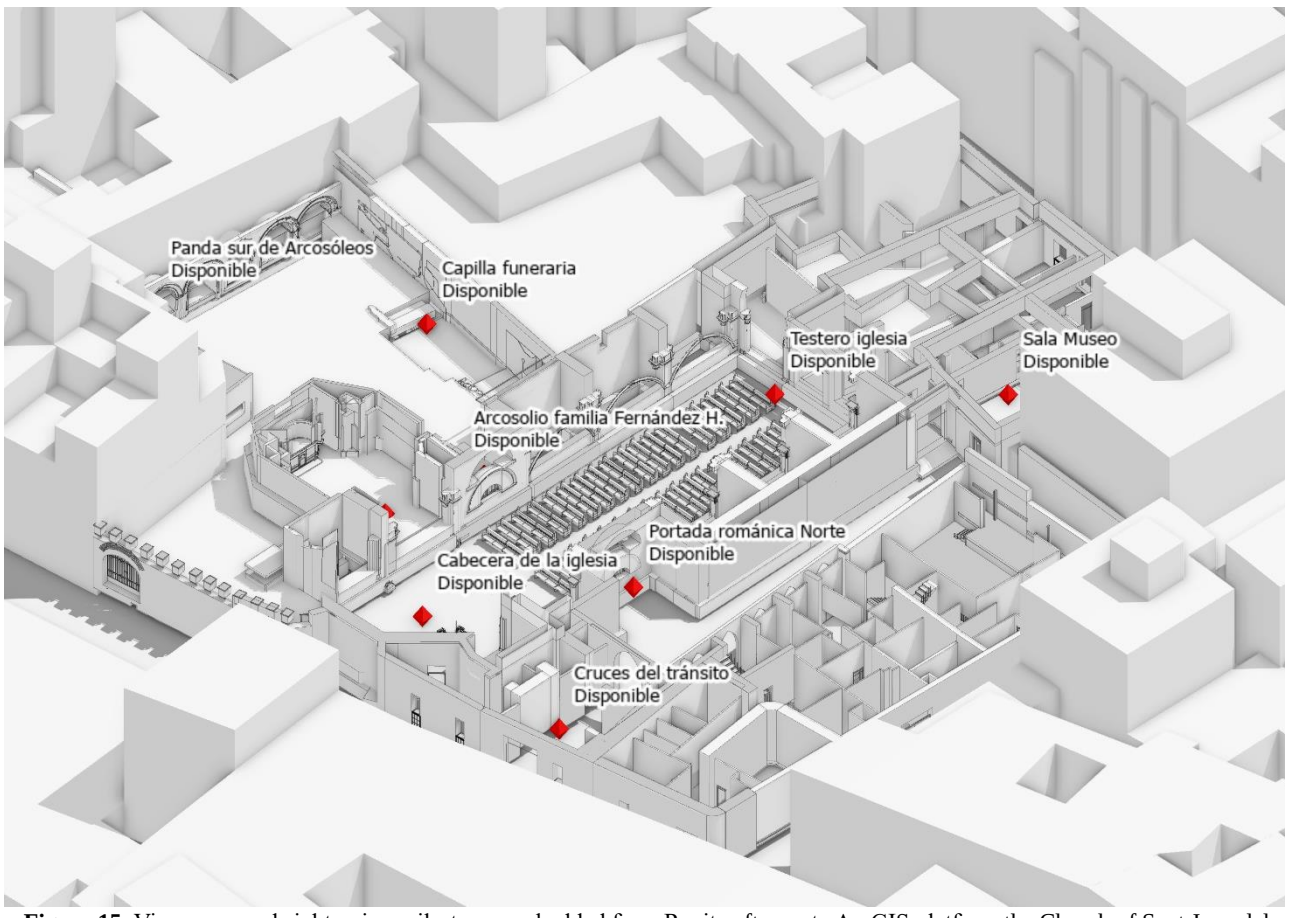


Figure 15. View proposed sightseeing milestones embedded from Revit software to ArcGIS platform the Church of Sant Juan del Hospital.

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REFERENCES

Arayaci, Y., J. Counsell, L. Mahdjoubi, G. Nagy, S. Hawas and K. Dewidar, 2017, Heritage Building Information Modelling (Londres y Nueva York: Routledge Taylor& Francis Group).

Baggio, R. and Scaglione, M., 2017, Strategic Visitor Flows and destination management. Proceedings of Information and Communication Technologies in Tourism 2017 Conference (ENTER 2017), Rome, Italy, January 24-26, 2017. doi: 10.1007/s40558-017-0096-1.

Bruno, N., Rechichi, F., Achille, C., Zerbi, A., Roncella, R., and Fassi F. (2020). Integration of historical GIS data in a HBIM system The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLIII-B4.

Bruno, S., de Fino, M. and Fatiguso, F. (2018). Historic Building Information Modelling: performance assessment for diagnosis-aided information modelling and management. Automation in Construction, 86: pp. 256-276

Chenaux, A., Murphy, M., Pavia, S., Fai, S., Molnar, T., Cahill, J., Lenihan, S., and Corns, A. (2019). A review of 3D GIS for use in creating virtual historic Dublin International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XLII-2/W9.

Collado, A., Marqués-Mateu, A., Viñals, J.M., Salvador-García, E., and Sanasaryan, A. (2022). Detección y cuantificación automática de visitantes para la gestión inteligente de atractivos turísticos. Congress proceedings, 3rd UNWTO Conference on Smart Destinations Valencia, 21-23 November 2022. pp 382

Fassi, F., Mandelli A., Teruggi S., Rechichi F., Fiorillo F. and Achille, C. (2016). VR for Cultural Heritage A VR-WEB-BIM for the Future Maintenance of Milan's Cathedral. In: L.T. De Paolis and A. Mongelli (ed.), International Conference on Augmented Reality, Virtual Reality and Computer Graphics. Springer International Publishing Switzerland

García-Hernández, M., 2003. Turismo y conjuntos monumentales: capacidad de acogida turística y gestión de flujos de visitantes. Valencia:Tirant lo Blanch.

Historic England, 2017. BIM for Heritage. Developing a Historic Building Information Model (Swindon: Historic England).

Le Corre, N., Le Berre, S., Brigand, L. y Peuziat, I., 2012., Comment étudier et suivre la fréquentation dans les espaces littoraux, marins et insulaires? De l'état de l'art à une vision prospective de la recherche. EchoGéo, 19. doi: 10.4000/echogeo.12749.

Lo Turco, M., Santagati, C., Parrinello, S., Valenti, G.M.;and Inzerillo, L., 2016, BIM e beni architettonici: verso una metodologia operativa per la conoscenza e la gestione del patrimonio culturale. Disegnare-con, 9(16), 1-9.

López González, Mª C and Máñez Testor S. (2020): "Revisión y nuevas contribuciones al límite meridional y oriental de la segunda judería de XXX y fijación de los límites de la tercera y última judería: 1390-1392-1492" Sefarad: Revista de Estudios Hebraicos y Sefardíes, Año 80, Nº. 1, 2020, págs. 25-54

Manning, R.E. and S.R. Lawson, 2002, Carrying Capacity as “Informed Judg¬ment”: The Values of Science and the Science of Values. An International Journal for Decision Makers, Scientists and Environmental Auditors, 30 (2), 157-168.

Martín Talaverano, R. and Murillo Fragero, J. I. (2020). Historical and archaeological consideration in the creation of HBIM models. Previous Studies. VII Seminar of strategies for the knowledge of the architectural heritage. Seville.

Mascort-Albea, J., Ruiz-Jaramillo, J., López Larrínaga, F., and de la Peña Bernal, A. (2016). Seville, World Heritage: An Interactive Cultural Guide for Mobile Devices. Journal PH, 90: pp.152–168.

Nguyen, S. H. and Kolbe, T. H., 2021. Modelling changes, stakeholders, and their relations in semantic 3D City Models. ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume VIII-4/W2-2021. 16th 3D Geo Info Conference 2021, 11–14 October 2021, New York City, USA. https://doi.org/10.5194/isprs-annals-VIII-4-W2-2021-137-2021

Pavel T. (2016) BIM, GIS, and semantic models of cultural heritage buildings. Geoinformatics FCE CTU 15(2).

Pinto Puerto, F., (coord.) 2021. Modelos digitales de información en la tutela sostenible del patrimonio cultural. Contribución al conocimiento e innovación social. Universidad de Sevilla

Ponnusamy, A. (n.f.), CVLIB. A simple, high level, easy to use, open-source Computer Vision library for Python. Fecha de acceso: mayo 2022. https://www.cvlib.net/.

Quintanilla Castaña, M. (2022). Digital graphic inventory of the Mudéjar architectural heritage in Aragon. Doctoral thesis. University of Zaragoza (Zaragoza) (Unpublished)

Salvador-García, E. (2020). Protocolo HBIM para una gestión eficiente del uso público del patrimonio arquitectónico. Universitat Politècnica de València, València. Tesis Doctoral. Disponible en: https://riunet.upv.es/handle/10251/146811.

Salvador-García, E. Viñals Blasco, M. J.; García-Valldecabres, J., (2020). Potential of HBIM to improve the efficiency of visitor flow management in heritage sites. Towards smart heritage management. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 1, XLIV-M, pp. 451-456.

Salvador-García, E., Viñals, J.M., García-Valldecabres, J (2022). La estimación y gestión de la capacidad de carga recreativa de los atractivos turísticos monumentales a partir del uso de HBIM detección y cuantificación automática de visitantes

para la gestión inteligente de atractivos turísticos. Congress proceedings, 3rd UNWTO Conference on Smart Destinations Valencia, 21-23 November 2022. pp 560-567

Spenceley, A., Philipp Schägner, J., Engels, B., (eds.), 2021, Visitors Count! Guidance for protected areas on the economic analysis of visitation. Ed. UNESCO and the German Federal Agency for Nature Conservation, 113 pp.

Vaishnavi, V., Kuechler, W. S. (2004). Design Science Research in Information Systems. Association for Information Systems, Eds. Petter. p. 66.

Wang, W., Kumar, N., Chen, J., Gong, Z., Kong, X., Wei, W., Gao, H. (2020). Realizing the potential of the internet of things for smart tourism with 5G and AI. IEEE Network, 34(6), 295-301. doi: 10.1109/MNET.011.2000250.

Yang, X., Grussenmeyer, P., Koehl, M., Macher, H., Murtiyoso, A., Landes, T. (2020). Review of built heritage modelling: Integration of HBIM and other information techniques. Journal of cultural heritage 4: pp. 350-360.

Zerbinatti, M., Fasana, S. (2022). Approaches Proposal for Tools Coordinating in Maintenance and Reuse of Architectural Heritage. A Case Study on Urban Complexes of Modern Architectural Heritage. In: Calabrò, F., Della

Zupic I., Čater, T. (2015). Métodos bibliométricos en gestión y organización. Métodos de investigación organizacional, 18(3): 429-472.